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Research Article

Evaluation of Integrated nutrient management practices on growth, yield parameters and yield of improved traditional rice in the western zone of Tamil Nadu

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Abstract
Farmers have recently relied on chemical fertilizers, particularly macronutrients, to boost rice yields. It leads to many problems, mainly rapidly declining soil fertility, soil and water quality, resulting in global environmental issues. With this view, a study aimed to evaluate different organic manures and inorganic fertilizers in an integrated manner and their effect on increasing rice (CO 57) yield. The study was conducted on Wetland farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, during *Early kar*, 2023. The experiment was conducted in randomized block design (RBD), and it had three replications and twelve treatments. The treatments included nutrient management practices and foliar spray of micronutrients. The results revealed that higher plant height (85.0 cm), total number of tillers m^{-2} (298), Leaf area index (4.99) and dry matter production (5298 kg ha^{-1}), number of productive tillers m^{-2} (309), number of filled grains $panicle^{-1}$ (176) and 1000 grain weight (22.00 g), grain yield (3972 kg ha^{-1}) and straw yield (5798 kg ha^{-1}) were recorded with the combined application of 50 % recommended dose of nitrogen through inorganic fertilizer + 50 % recommended dose of nitrogen through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at tillering, PI and flowering stage (T_{11}) compared to other practices. The use of inorganic fertilizers combined with organic sources applied to the soil enhanced plant quality and yield sustainably without harming the natural ecosystem. Integrated nutrient management (INM) in rice significantly improved overall crop response, leading to optimal growth characteristics and yield attributes.

Keywords: Growth, Improved traditional rice, Integrated Nutrient Management, Yield parameters, Yield

INTRODUCTION

Rice is the most important cereal crop in many Asian countries and is a primary food source for more than half of the world's population. Rice is a good source of lipids, carbohydrates, mildly concentrated protein and B complex vitamins like riboflavin, thiamine and niacin (Sen *et al*., 2020). Traditional rice has high medicinal values that prevent human disorders (Fresco, 2005). India has the largest area under rice cultivation and is

the second largest producer in the world after China. In India rice occupied an area of 46.3 m.ha with a production of 129.5 mt and productivity of 2798 kg ha^{-1} (Indiastat, 2021-2022).

In Tamil Nadu, many traditional rice varieties are cultivated, such as Karungkuruvai, Karuppu kavuni, Mappillai samba, Kichili samba, Kattuyanam, Thooyamalli, Seeraga samba, Kullakar, Navara, Poongar, Thanga samba, Vellaikavuni, Kichadi samba, Rajamannar, Sembuli samba, Norungan, Chithiraikar, Paalthondi, Maranel, Salem samba, Kallurundaikar and Illupaipoo samba (Jalapathi *et al*., 2022). Karuppu kavuni has higher antioxidant and anthocyanin content than traditional rice varieties. It controls diabetes, obesity, and heart attacks and inhibits cancer by perhaps serving as a chemo-preventive agent (Koperundevi *et al*., 2022). Karuppu kavuni was photosensitive variety. It is cultivated during *Navarai* and *Samba* seasons (Radha *et al*., 2022). Meanwhile, the improved black kavuni rice variety CO 57 released from Tamil Nadu Agricultural University (TNAU) in 2023 is photo-insensitive and suitable for all seasons. It gives more yield (55.74 %) than black kavuni rice. Its high fibre, protein and low carbohydrate content give it great nutritional value. It inhibits a rise in blood sugar levels because of its lower glycemic index. Due to the presence of flavonoids also has an anticancer property (TNAU Agritech Portal, 2023).

High-yielding rice varieties remove higher amounts of macro and micronutrients from the soil (Saleque *et al*., 2004). Nutrient management is a crucial component of the soil and plant management system. Farmers have recently relied on chemical fertilizers, particularly macronutrients, to boost rice yields. It leads to many problems, mainly rapidly declining soil fertility, damaging soil physicochemical properties, and water quality, resulting in global environmental issues (Selim, 2018). Thus, applying organic manures restores soil health and sustains productivity over longer time. Using organic manures with chemical fertilizers may have reduced N loss and increased availability for longer periods (Swamy *et al*., 2020).

The trend towards higher-yielding, more intense crop production necessitates greater importance and use of micronutrients. In India, agricultural products with lower micronutrient content have failed to meet the human nutrition requirements for Zn and recognizing the crucial role of Zn and Fe in crop production, applying these for the growth and yield (Sudhagar Rao *et al*., 2019). About 35% of Indian soils are deficient in Fe and 11% are deficient in Zn (Katyal and Sharma, 2019). Foliar application of Zn and Fe is essential for growth and development and increasing nutrition in grains. Zn is necessary for pollen formation, protein synthesis, photosynthesis, and the integrity of cellular membranes. Fe is crucial for many physiological and biochemical pathways, including respiration, photosynthesis, DNA synthesis, and chlorophyll synthesis (Afreen *et al*., 2021). Using chemical fertilizers without adding organic manure or micronutrients causes soil nutrient deficits (Paramesh *et al*., 2023). Application of organic manures, chemical fertilizers, and foliar application of Fe and Zn positively influence the yield without affecting the soil nutrient balance. Hence, the present research aimed to evaluate the effect of integrated nutrient management practices on growth, yield parameters and yield of improved traditional rice black kavuni variety CO 57.

MATERIALS AND METHODS

The field experiment was carried out in Wet Land Farm, Department of Agronomy, TNAU, Coimbatore during *Early kar* (April - August, 2023). The experimental field is located at 11°01'06" N Latitude, 76°58'21" E Longitude and 426.7 m above MSL. The experimental design consisted of twelve treatments laid out in randomized block design (RBD) with three replications. The treatments comprised of T_1- Control (Without fertilizer), T_2 - 100% RDN through inorganic fertilizer, T_3 -50 % RDN through inorganic fertilizer + 50 % RDN through FYM, T_4 - 50 % RDN through inorganic fertilizer + 50 % RDN through poultry manure, T_5 - 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost, T_6 - 50 % RDN through inorganic fertilizer + 25 % RDN through poultry manure + 25 % RDN through vermicompost, T_7 - T_4 + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering and PI stage, T_8 - T_5 + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering and PI stage, T_9 - T_6 + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering and PI stage, T_{10} - T_4 + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering, PI and Flowering stage, T_{11} - T_5 + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering, PI and Flowering stage and T_{12} - T_6 + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering, PI and Flowering stage.

The rice variety CO 57 (Improved black kavuni) was used in this experiment. Organic manures were applied basally as per the treatment schedule before transplanting rice seedlings. The recommended dose of N (RDN) (150 kg ha^{-1}) was applied as per the treatment schedule. N and K were applied at basal, tillering, panicle initiation and heading stages. A full dose of P was applied at basal. N content in different organic manures was analysed before the quantity was determined. Farm yard manure (FYM), poultry manure and vermicompost nitrogen contents were 0.43, 2.92 and 2.26 per cent, respectively.

Plant height was measured by recording the height from the base of the plant to the tip of the longest leaf. The number of tillers per m^{-2} was counted from each sampled plot. The plant samples were carefully pulled from the field, dried in an oven at 70˚C for 48 hours, and weighed for their dry weight. The plant's leaf area was measured using the LI-COR 3000 leaf area meter.

The number of productive tillers per m^2 was counted in each plot. At the time of harvest, yield parameters and yield were calculated. Top of FormThe following formula was used to determine the Harvest index (HI): where economical yield was grain yield and biological yield was sum of grain yield and straw yield (Donald and Hamblin, 1976).

$$\text{Harvest Index} = \frac{\text{Economical yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \quad \text{Eq.1}$$

Statistical analysis

The data collected on different parameters were analyzed using R software version 4.2.0 (R Studio 2022.02.3+492) to identify significant differences at a 5% level in a Randomized Block Design. This analysis aimed to assess significant variations among the means of 12 treatments.

RESULTS AND DISCUSSION

Growth parameters

The highest plant height (85.0 cm), total number of tillers m^{-2} (298), Leaf area index (LAI) (4.99) and dry matter production (DMP) (5298 kg ha^{-1}) recorded with the application of 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering, PI and Flowering stage (T_{11}) which was on par with 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ & 1 % $FeSO_4$ at Tillering and PI stage (T_8) at 60 DAT. The lower plant height, total no of tillers m^{-2}, LAI and DMP were recorded under control (T_1) are mentioned in Table 1. Organic and inorganic fertilizers gradually release nutrients to the plant, enhancing the soil environment for improved root penetration. This facilitates better moisture absorption and nutrients, increasing plant height and growth attributes. The increased growth attributes due to nutrient availability resulting from integrated nutrient management practices were documented by Diwedi *et al*. (2024), specifically in transplanted rice treated with organic and inorganic nutrient sources along with foliar-sprayed micronutrients.

N is directly or indirectly involved in the enlargement and division of new cells and tissue production, which contributes to the growth characteristics, particularly the increase in tiller numbers The most common and efficient method to increase the number of tillers is to apply N, which raises the cytokinin content in tiller nodes and promotes the germination of tiller primordial. Rao *et al*. (2020) also stated that the application of 125% RDF + 25% vermicompost in rice resulted in a higher number of tillers m^{-2}.

The increase in LAI might be due to adequate nutrient supply from inorganic sources and vermicompost, enhancing the nutrient absorption capacity through improved root development and increased translocation of carbohydrates from the source to the growing grains. This leads to leaf expansion and ultimately increases the LAI. These results are supported by the study of Nayak et al. (2023), who reported that a higher LAI (4.84) in rice was observed due to the adequate nutrient supply from 75% soil test based inorganic nitrogen + 25% RDN through vermicompost.

The combined application of 50 % RDN through inorganic fertilizer, 50 % RDN through vermicompost and foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ increases N availability leading to increased leaf area, higher photoassimilates production and more dry matter accumulation. Indeed, the study conducted by Urmi *et al*. (2020) observed a similar trend of increased dry matter production in rice by applying 75% RDN through inorganic fertilizer and 25% RDN was applied through vermicompost. Top of FormPlants receive an adequate supply of nutrients through organic and inorganic sources, which allowed for rapid growth through root establishment and other metabolic processes. This improved metabolism of the synthesized carbohydrates into amino acids and proteins stimulates rapid cell division and elongation, increasing growth attributes. The findings closely resembled the results obtained by Nureti *et al*. (2024), who explored the impact of organic nutrients applied along with inorganic nutrient sources in rice and reported a significant rise in growth attributes.

Yield parameters

Yield attributes were significantly influenced by different nutrient management practices (Table 2). Application of 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering, PI and Flowering stage (T_{11}) registered higher number of productive tillers m^{-2} (309), number of filled grains $panicle^{-1}$ (176) and 1000 grain weight (22.00 g). However, treatment T_{11} was comparable with 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering and PI stage (T_8). Control (T_1) registered lower yield parameters. Applying organic manures combined with chemical fertilizers might have enhanced the soil's physical, chemical, and biological qualities. This could lead to a faster utilization of applied nutrients and an increase in the efficiency of native nutrients, promoting greater plant development and rice yield component. Higher productive tillers/m^2 might result from the application of inorganic N fertilizer and the slow release of nutrients through vermicompost. Singh *et al*. (2018) reported that integrated application of organic manures and inorganic fertilizer gave significantly higher yield parameters. This could be due to the availability of nutrients

Table 1. Effect of integrated nutrient management practices on growth parameters of improved traditional rice (Black kavuni)

Treatments	Growth parameters			
	Plant height (cm)	Total number of tillers m^{-2}	LAI	DMP (kg ha^{-1})
T_1 – Control (Without fertilizer)	57.3^{g}	173^{h}	3.12^{g}	3448^{f}
T_2 - 100% RDN through inorganic fertilizer	$70.9c^{de}$	239^{de}	4.16^{bcde}	4293^{de}
T_3 - 50% RDN through inorganic fertilizer + 50% RDN through FYM	63.1^{f}	198^{g}	3.55^{f}	3997^{e}
T_4 - 50% RDN through inorganic fertilizer + 50% RDN through poultry manure	72.7^{bcd}	243^{cd}	4.23^{bcd}	4504^{cd}
T_5 - 50% RDN through inorganic fertilizer +50 % RDN through vermicompost	78.2^{b}	272^{b}	4.51^{b}	4889^{b}
T_6 - 50% RDN through inorganic fertilizer + 25% RDN through poultry manure + 25% RDN through vermicompost	64.2^{f}	$208f^{g}$	3.82^{ef}	4082^{e}
T_7 - T_4 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering & PI stage	74.0^{bc}	$260b^{c}$	4.36^{bc}	4725^{bc}
T_8 - T_5 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering & PI stage	84.2^{a}	294^{a}	4.93^{a}	5280^{a}
T_9 - T_6 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering & PI stage	66.4^{ef}	217^{fg}	3.96^{de}	4115^{e}
T_{10} - T_4 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering, PI & flowering stage	74.9^{bc}	264^{b}	4.40^{b}	4760^{bc}
T_{11} - T_5 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering, PI & flowering stage	85.0^{a}	298^{a}	4.99^{a}	5298^{a}
T_{12} - T_6 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering, PI & flowering stage	67.2^{def}	220^{ef}	4.00^{cde}	4138^{de}
Sed	2.8	9	0.19	177
CD (P=0.05)	5.8	20	0.38	367

(Same letters are comparable with each other)

from INM practices.

Organic manures release nutrients gradually through microbial mineralization, while inorganic fertilizers supply nutrients immediately after application. This ensures nutrient availability throughout the grain filling stage of crops. Sufficient nitrogen availability is essential for rice grain development and increased filled grains per panicle. Senthamizhkumaran *et al*. (2021) reported that the combined application of organic and inorganic N sources ensures nutrient availability, ultimately increasing rice yield parameters. The application of vermicompost, with its slow release and continuous supply of nutrients in balanced quantities throughout various growth stages enable rice plants to assimilate sufficient photosynthetic products. This leads to increased dry matter and source capacity, resulting in more panicles with a higher number of fertile grains. Neti *et al*. (2022) suggested that applying organic manures, which slowly release nutrients throughout the crop growth, results in higher yield attributes and yield.

Grain yield, straw yield and harvest index

The highest grain yield (3972 kg ha^{-1}), straw yield (5798 kg ha^{-1}) and harvest index (0.41) were recorded with the application of 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering, PI and flowering stage (T_{11}). However, T_{11} was statistically on par with 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at Tillering and PI stage (T_8) (Fig. 1). Control (T_1) registered a significantly lower yield for treatment without the application of nutrients. The higher yield could result from greater yield traits, such as number of productive tillers m^{-2}, number of filled grains $panicle^{-1}$ and 1000 grain weight. This could be due to improved photosynthate translocation from source to sink due to increased N absorption, which enables quick and easy translocation. Moe *et al*. (2019) also reported that the higher rice grain yield was highly depends on these yield attributes. Combining organic and inorganic nutrients to adequately supply N during critical stages is essential for increasing rice yield. Nitrogen is a key component of proteins, amino acid, nucleic acids and chlorophyll and is necessary for the growth and maximum rice production. Shankar *et al*. (2020) found that an increase in rice yield with an adequate supply of N through both organic inorganic sources of

Table 2. Effect of integrated nutrient management practices on yield parameters of improved traditional rice (Black kavuni)

Treatments	Yield traits		
	No. of productive tillers m^{-2}	No. of filled grains panicle $^{-1}$	1000 grain weight (g.)
T_1 – Control (Without fertilizer)	148^{f}	96^{g}	20.50
T_2 - 100% RDN through inorganic fertilizer	224^{d}	125^{de}	21.32
T_3 - 50% RDN through inorganic fertilizer + 50% RDN through FYM	194^{e}	109^{f}	20.89
T_4 - 50% RDN through inorganic fertilizer + 50% RDN through poultry manure	246^{c}	131^{d}	21.40
T_5 - 50% RDN through inorganic fertilizer +50 % RDN through vermicompost	282^{b}	161^{b}	21.60
T_6 - 50% RDN through inorganic fertilizer + 25% RDN through poultry manure + 25% RDN through vermicompost	201^{e}	113^{f}	20.95
T_7 - T_4 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering & PI stage	258^{c}	144^{c}	21.42
T_8 - T_5 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering & PI stage	301^{a}	174^{a}	21.89
T_9 - T_6 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering & PI stage	207^{de}	115^{ef}	21.20
T_{10} - T_4 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering, PI & flowering stage	261^{c}	148^{c}	21.47
T_{11} - T_5 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering, PI & flowering stage	309^{a}	176^{a}	22.00
T_{12} - T_6 + Foliar application of 0.5% $ZnSO_4$ & 1% $FeSO_4$ at tillering, PI & flowering stage	211^{de}	119^{ef}	21.25
Sed	9	5	1.06
CD (P=0.05)	18	10	NS

(Same letters are comparable with each other)

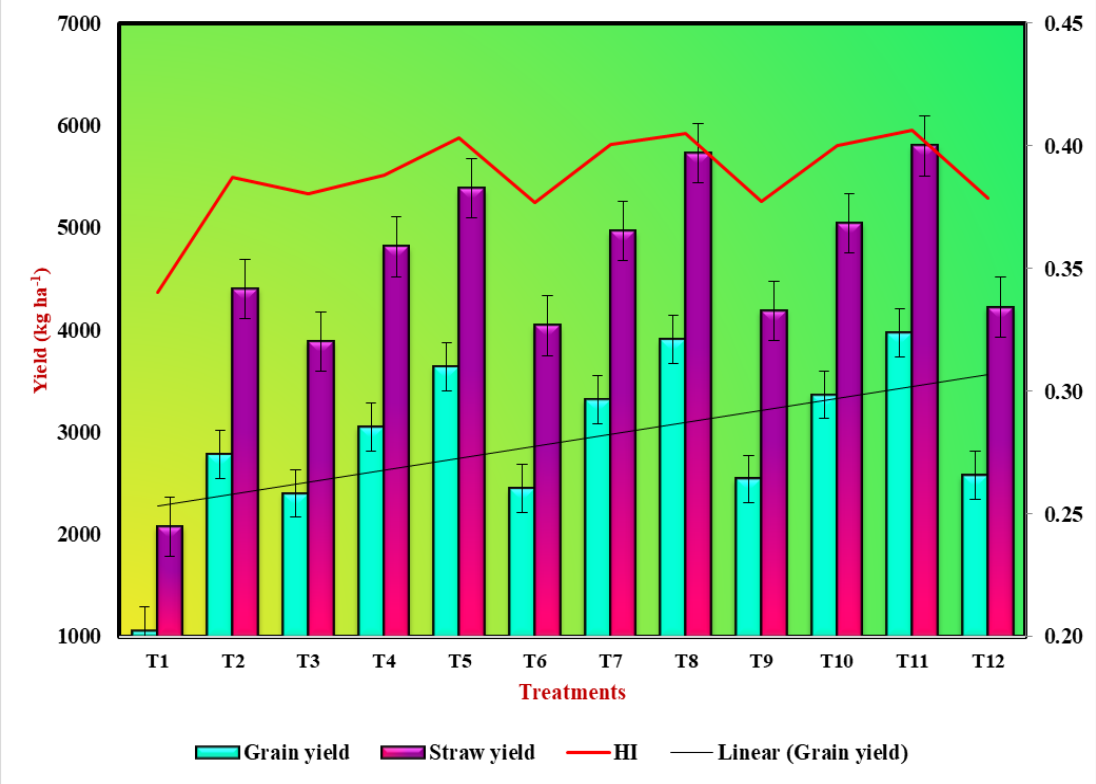

Fig. 1. *Effect of integrated nutrient management practices on yield of improved traditional rice (Black kavuni)*

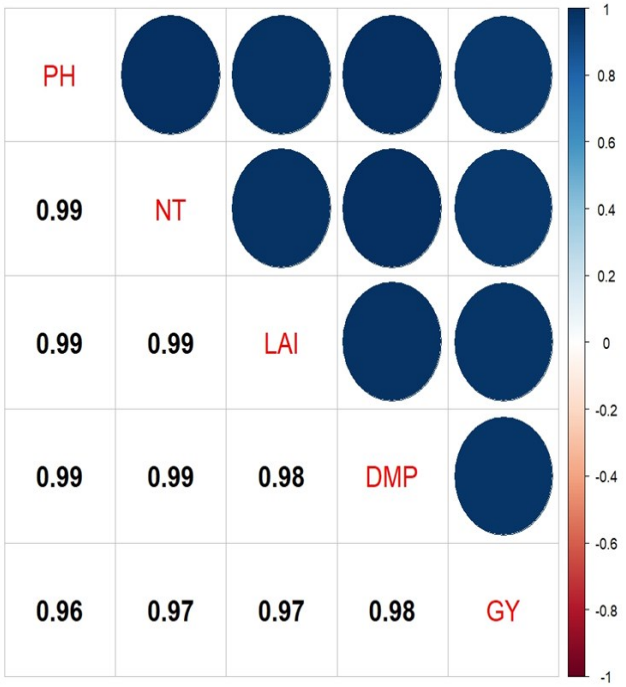

Fig. 2. *Correlation analysis of growth parameters and yield of improved traditional rice (Black kavuni);(PH- Plant height (cm), NT- No. of tillers m^{-2}, LAI- Leaf Area Index, DMP- Dry Matter Production (kg ha^{-1}) and GY- Grain Yield (kg ha^{-1}).*

nutrients.

The positive effect of Zn application on yield could be attributed to its catalytic or stimulatory actions on most plant physiological and metabolic processes. Foliar applied Zn and Fe are essential for the production of IAA and help to initiate the primordial reproductive part and portioning of photosynthesis, which might have resulted in enhanced yield. Geetha *et al*. (2020) documented similar outcomes, which showed a foliar spray of Zn and Fe increases grain yield. The most efficient source of nitrogen has been found to be the combined use of chemical fertilizer due to the rapid supply of nutrients and organic manures due to steady supply of nutrients for prolonged periods, which resulted in maximum grain and straw yield (Ram *et al*., 2020).

Correlation analysis

Correlation analysis carried out to assess the relationship between growth attributes and yield (Fig. 2) showed that plant height (0.96), number of tillers m^{-2} (0.97), LAI (0.97) and DMP (0.98) of improved traditional rice observed were positively correlated with grain yield. These results indicate that plant height and the number of tillers m-2, LAI, and DMP are crucial for achieving a higher yield. Russinga et al. (2020); Saketh *et al*. (2023) also noted that growth attributes are correlated with grain yield.

Conclusion

The results revealed that the application of 50 % RDN through inorganic fertilizer + 50 % RDN through vermicompost + foliar spray of 0.5 % $ZnSO_4$ + 1 % $FeSO_4$ at tillering, PI and flowering stage (T_{11}) was most effective in increasing growth, yield parameters and yield of rice (CO 57) during *Early kar* (April - August 2023) season. INM was an effective approach for enhancing soil health, promoting plant growth and achieving sustainable crop production. It will reduce the reliance on chemical fertilizers without compromising paddy yield.

Conflict of interest

The authors declared that they have no conflicts of interest.

REFERENCES

1. Afreen, S., Arun Kumar, Kumari Punam Sinha, Mukesh Kumar & Singh, P.K. (2021). Evaluation of zinc and iron treatment on growth and seed yield in paddy (*Oryza sativa* L.). *The Pharma Innovation Journal*, 10(10), 61-65.
2. Diwedi, N., Singh, S., Pandey, D., Singh, P. K., Chanda, S.S., Tiwari, H. N., Singh, D. K. and Gajendra Singh. (2024). The Effect of Integrated Nutrient Management on Growth, Yield Attributes and Yield of Transplanted Rice under Irrigated Condition (*Oryza sativa* L.). *Journal of Experimental Agriculture International,* 46(1), 27-36. DOI: 10.9734/jeai/2024/v46i12288
3. Donald, C.M. & J. Hamblin. (1976).The biological yields and harvest index of cereals as agronomic and plant breeding criteria. *Adv. Agron*, 28, 361-405. https://doi.org/10.1016/S0065-2113(08)60559-3.
4. Fresco, L. (2005). Rice is life. *Journal of Food Composition and Analysis*, 18(4), 249-253. DOI:10.1016/J.JFCA.2004.09.006.
5. Geetha, B., Balanagoudar, S. R., Gaddi, A. K., Manjunatha, B. & Ramesh, Y. M. (2020). Effect of integrated plant nutrient supply system on growth, yield and economics of dry-direct seeded rice. *International Journal of Communication Systems*, 8(3), 2241-2244. DOI:10.22271/chemi.2020.v8.i3af.9544
6. Indiastat. (2021-2022). https://www.indiastat.com/data/agriculture.
7. Jalapathi, E., Jerlin, R., Raja, K., Raveendran, M. & Thiruvengadam V. (2022). Evaluation of Biochemical Properties of Traditional Rice Varieties of Tamil Nadu. *International Journal of Plant & Soil Science*, 34(17), 39-46. DOI: 10.9734/ijpss/2022/v34i1731034.
8. Katyal, J.C. & Sharma, B.D. (2019). DTPA-extractable and total Zn, Cu, Mn, and Fe in Indian soils and their association with some soil properties. *Geoderma*, 49 (1&2), 165-179. https://doi.org/10.1016/0016-7061(91)90099-F
9. Koperundevi, V., Arunasree, A. & Bhuvana., S. (2022). Effect on Physio-Chemical, Textural and Nutritional qualities of Pressure parboiled karuppukavuni rice (*Oryza sativa* L. *indica*). *Biological Forum-An International Journal*, 14(3), 274-281.
10. Moe, K., Moh, S.M., Htwe, A.Z., Kajihara, Y. & Yamakawa T. (2019). Effects of integrated organic and inorganic ferti-

lizers on yield and growth parameters of rice varieties. *Rice Sci.,* 26, 309–318 . doi: 10.1016/j.rsci.2019.08.005

11. Nayak, R., Satapathy, M., Bamashankar, R., Rajendra Kumar, P., Rabindra Kumar, P. & Satyananda, J. (2023). Effect of site specific nitrogen management on growth, yield attributes and yield of kharif rice (*Oryza sativa* L.) in rice-groundnut cropping system in Odisha. *The Pharma Innovation Journal*, 12(2), 2063-2067
12. Neti, S., Sidar, R.S., Singh, V.K. & Divyanshi Yadav. (2022). Effect of integrated nutrient management on rice (*Oryza sativa* L.) yield under Surguja district. *The Pharma Innovation Journal*, 11(7), 3473-3476.
13. Nureti, V., Thakur, A., Kumar, N., Chandraker, T., Singh, D.P. & Verma, K. (2024). Effect of inorganic and organic sources of nutrients on yield and economics of direct seeded rice under rainfed situations. *The Pharma Innovation Journal*, 13(3), 340-343.
14. Paramesh, V., Parveen Kumar, Tejasvi Bhagat, Arun Jyoti Nath, Kallakeri Kannappa Manohara, Bappa Das, Brijesh Fal Desai, Prakash Kumar Jha & P. V. Vara Prasad. (2023). Integrated Nutrient Management Enhances Yield, Improves Soil Quality, and Conserves Energy under the Lowland Rice–Rice Cropping System. *Agronomy*, 13 (1557), 1-16. https://doi.org/10.3390/agronomy13061557.
15. Radha, P., Selvanayaki, S., Tilak, M. & Gurusamy, A. (2022). Medicinal Properties of Traditional Rice Varieties. *Just Agriculture*, 3(3), 1-3.
16. Ram, M.S., Shankar, T., Maitra, S., Adhikary, R. & Swamy, G.V.V.S.N. (2020). Productivity, nutrient uptake and nutrient use efficiency of summer rice (*Oryza sativa*) as influenced by integrated nutrient management practices. *Crop Res,* 55(3 & 4), 65-72. DOI:10.31830/2454-1761.2020.013.
17. Rao, R., Singh, N.B., Pandey, D. and Singh, M.P. (2020). Effect of integrated nutrient management on productivity and profitability of rice under SRI. *Journal of Pharmacognosy and Phytochemistry,* 9(5), 665-667.
18. Russinga, A.M., Srividhya, A., Reddy, V.L.N. & Latha, P. (2020). Correlation Studies on Yield and Yield Contributing Traits in Rice (*Oryza sativa* L.). *Ind. J. Pure App. Biosci*, 8(5), 531-538. DOI: http://dx.doi.org/10.18782/2582-2845.8334.
19. Saketh, T., Gouri Shankar, V., Srinivas, B. and Har, Y. (2023). Correlation and Path Coefficient Studies for Grain Yield and Yield Components in Rice (*Oryza sativa* L.). *International Journal of Plant & Soil Science,* 35(19), 1549 -1558 DOI: 10.9734/IJPSS/2023/v35i193700.
20. Saleque M.A., Abedin M.J., Bhuiyan N.I., Saman S.K. & Panaullah G.M. (2004). Long-term effects of inorganic and organic fertilizer sources on yield and nutrient accumulation of low land rice. *Field Crops Res*, 86, 53–65. http://dx.doi.org/10.1016/S0378-4290(03)00119-9.
21. Selim, M. (2018). Potential role of cropping system and integrated nutrient management on nutrients uptake and utilization by maize grown in calcareous soil. *Egyptian Journal of Agronomy*, 40 (3), 297–312. Doi: 10.21608/AGRO.2018.6277.1134.
22. Sen, S., Chakraborty, R. & Kalita, P. (2022). Rice - not just a staple food: A comprehensive review on its phytochemicals and therapeutic potential. *Trends in Food Science & Technology,* 97, 265-285. https://doi.org/10.1016/j.tifs.2020.01.022.
23. Senthamizhkumaran, V.R., Santhy, P., Selvi, D., Maragatham, N., Kalaiselvi, T. & Sabarinathan, K.G. (2021). Effect of organic and inorganic nutrients on rice (*Oryza sativa* var. CO 51) productivity and soil fertility in the Western zone of Tamil Nadu, India. 13(14), 1488-1498. https://doi.org/10.31018/jans.v13i4.3118
24. Shankar, T., Maitra, S., Sairam, M. & Mahapatra, R. (2020). Influence of integrated nutrient management on growth and yield attributes of summer rice (*Oryza sativa* L.). *Crop Res*, 55(1 & 2), 1-5. DOI:10.31830/2454-1761.2020.001
25. Singh, S.K., Maneesh Kumar, Singh, R.P., Bohra, J.S., Srivastava, J.P., Singh, S.P. & Singh, Y.V. (2018). Conjoint Application of Organic and Inorganic Sources of Nutrients on Yield, Nutrient Uptake and Soil Fertility under Rice (*Oryza sativa*)–Wheat (*Triticum aestivum*) System. *Journal of the Indian Society of Soil Science*, 66 (3), 287-294. DOI: 10.5958/0974-0228.2018.00035.
26. Sudhagar Rao, G.B., Rex Immanuel, R., Ramesh, S., Baradhan, G. & Sureshkumar, S.M. (2019). Effect of zinc and iron fertilization on growth and development of rice. *Plant Archives*, 19 (2), 1877-1880.
27. Swamy, G.V.V.S.N. Masina Sairam, Tanmoy Shankar, Sagar Maitra, Sameer Mohapatra & Sailasuta Sahu. (2020). Various Approaches for Nutrient Management in Rice (*Oryza sativa* L.). *Agro Economist - An International Journal*, 7(2), 123-127.
28. TNAU Agritech Portal. (2023). https://agritech.tnau.ac.in/agriculture/CO%2057.html.
29. Urmi, T.A., Rahman, M.M., Islam, M.M., Islam, M.A., Jahan, N.A., Mia, M.A.B., Akhter, S., Siddiqui, M.H. & Kalaji, H.M. (2022). Integrated Nutrient Management for Rice Yield, Soil Fertility, and Carbon Sequestration. *Plants,* 11 (1):138. doi: 10.3390/plants11010138.